2 Background

Recent incidents throughout North America and the world, including Australia, Russia, Saudi Arabia, and South America, have highlighted the threats to pipelines from SCC. In the United States, SCC failures on hazardous liquid pipelines have been less frequent when compared with SCC occurrences on natural gas pipelines. However, three SCC-caused failures of hazardous liquid pipelines have occurred in 2003. Another hazardous liquid pipeline operator has reported finding significant[1] SCC defects.

Figure 2-1 Gas Pipeline SCC

Catastrophic Ruptures, Williams Pipeline, May 1 and December 13, 2003
(http://www.corrosion-doctors.org/Pipeline/Williams-explosion.htm)

Extensive industry research has been conducted related to understanding the mechanism(s) by which SCC affects pipelines and the many factors that pertain to the initiation and growth of SCC. Other research has been performed regarding detection methods, evaluation procedures, and mitigation measures. While much remains to be learned about the factors affecting cracking behavior and methods to detect, evaluate, and mitigate SCC, an understanding is developing within the pipeline industry about how to effectively manage the SCC integrity threat. This industry understanding is being documented by organizations such as ASME and NACE International.

1 A significant stress corrosion crack is defined as one that could potentially fail a hydrostatic test and pose a future integrity threat to the pipeline if not mitigated.

The Research and Special Programs Administration's Office of Pipeline Safety (OPS) issued an Advisory Bulletin on October 2, 2003 that reminds owners and operators of gas transmission and hazardous liquid pipelines to consider SCC as a risk factor when developing and implementing Integrity Management Plans.

2.1 Problem Statement

Federal regulations require pipeline operators to identify and address the range of risks to which pipelines are subjected, including risks associated with SCC. Inspectors need further guidance in determining if operator risk mitigation efforts are adequate. OPS recognizes the need for the industry to develop a standard procedure or procedures to assure SCC issues are handled in a consistent and appropriate manner. OPS also realizes that there is a need for federal inspectors and auditors to have guidance by which to assess the information provided by the various pipeline operators under their integrity programs.

Questions that need to be addressed include:

- What do we already understand about SCC and what do we need to know? (i.e., a knowledge gap analysis)
- Where is SCC found?
- What are the frequency and consequence of SCC-related failures?
- How is SCC detected and characterized?
- What are the susceptibility parameters of SCC?
- What tools exist for detecting SCC and what is their reliability?

To accomplish these goals, RSPA/OPS has requested that a comprehensive study of SCC be completed.

2.2 Project Scope Overview

The scope of the project is to conduct an overall "umbrella" study of SCC issues relating to pipeline integrity for both gas and liquid lines, including the history of SCC, level of risk, indicators of potential for SCC, detection methods, mitigation measures, assessment procedure, and regulatory procedures for evaluation of industry assessments.

The study was comprehensive in scope and involved coordination with major industry trade organizations, pipeline operators, pipeline regulators, and industry experts, both here in the United States and internationally. Known information on the subject of SCC has been assembled or identified, and any gaps in the efforts to understand, identify, assess, manage, mitigate, and regulate enforcement of SCC effects and efforts were identified.

Support of the study by all stakeholders has been critical for the successful outcome of the effort. The study was structured in such a way that public comment period(s) were allowed to ensure the outcome of those publicly reviewed portions of the study would be met with broad acceptance.

2.2.1 Phase 1

The first phase of the study was to prepare for an OPS-hosted SCC workshop held in Houston on December 2, 2003. RSPA/OPS and the National Association of Pipeline Safety Representatives (NAPSR) co-sponsored this workshop on SCC with the pipeline industry trade and technical associations (API, AOPL, INGAA, AGA, PRCI, and NACE International) to provide a forum for the discussion of SCC phenomena in both gas and hazardous liquid pipelines.

In preparation, initial consultation of government and industry contacts was conducted. After the workshop, comments and feedback were incorporated into the draft scope. The study outline was revised as needed in response to feedback provided during and after the workshop; Phase 1 efforts concluded on December 31, 2003.

2.2.2 Phase 2

The following activities were developed for Phase 2 of this study:

- Literature Review**:** Review existing documentation with regard to SCC history, research conducted to understand the mechanisms causing or contributing to SCC, and prevention, detection and mitigation of SCC.
- SCC Detection, Science, and History: Compile a report summarizing the history of SCC on pipelines, explaining the causes and factors contributing to SCC initiation and growth, and discussing methods for prevention, detection and mitigation of SCC on pipelines, including effectiveness of in-line inspection (ILI) tools and other in-the-bell-hole examination methods to detect SCC.
- Research Gap Analysis**:** Determine SCC-related R&D issues that warrant further research.
- Application of SCC Principles**:** Develop a practicable procedure regarding how to assess SCC in operating pipelines within the context of integrity management.
- Regulatory Practices in Foreign Countries**:** Summarize regulatory practices outside of the United States (i.e., Canada, United Kingdom, Norway, Australia, Russia, Saudi Arabia, and South America).
- Recommended Actions for Operator Response and Remediation**:** Identify recommended actions to be taken by pipeline operators to facilitate response and assure appropriate remedial measures are implemented following an SCC-related incident.
- Guidelines for Regulatory Response**:** Develop guidelines for regulatory oversight response in the event of SCC-related incidents.

2.3 Report Outline

As discussed in Chapter 3 of this report, the Literature Review uncovered a large body of documents available on various aspects of SCC. For organization purposes, a database was developed to classify these documents as described in Chapter 3. The understanding of the various aspects of SCC, stemming from the information contained in these documents, is included in following

chapters. Note that laboratory research, material testing, and detailed analytical investigations were not a part of this scope.

The understanding of the current knowledge base and associated practices concerning SCC was considered too broad a topic to be summarized in one chapter. Accordingly, this second scope item was broken into four separate chapters – Chapter 4; Understanding Stress Corrosion Cracking (SCC) in Pipelines; Chapter 5, Prevention of an SCC Problem; Chapter 6, Detection of SCC; and Chapter 7, Mitigation of SCC. The regulatory practices in the United States and other foreign countries are discussed in Chapter 8. Chapter 9 concludes the SCC review with a summary of the research needs related to the SCC problem.

Chapter 10 synthesizes the current knowledge base concerning SCC, both from the results of a questionnaire circulated to industry and information from interviews with a number of pipeline operators.

Chapter 11 presents a review of the OPS inspection protocols for an IM plan referencing SCC and discusses guidelines for oversight of the operator responses to these protocols.

Chapter 12 discusses the response to an in-service failure due to SCC.

Chapter 13 is a summary chapter concluding this study.